engines, air is passed through the engine inlet into the fan stage **12** where the air is compressed by means of rotating fan blades and fixed stators. More than one fan stage **12** may be provided. A portion of the fan air is then passed into a multistage compressor **14** where further compression of the air takes place, this air being combusted and passed through turbines which drive the fan and compressor stages, and ultimately being passed through a nozzle resulting in forward propulsive thrust from the engine. Another portion of the compressed fan air is fed into a bypass duct **16** to create additional thrust from the engine, the fan air being exhausted separately or being remixed with the main airstream and then being exhausted through the nozzle.

A pair of pressure sensitive transducers are connected to pressure probes located so as to measure the pressure in the fan discharge flow path and to respond to both the variations in amplitude and frequency of the pressure of the air which passes through the fan stage **12.** In FIG. **1** the pressure transducers are shown as pressure probes **18** and **20** connected respectively through pneumatic lines **22** and **24** to blocks labeled low response pressure sensor **26** and high response pressure sensor **28.** Although schematically shown as located in the fan bypass duct **16,** the pressure probes **18** and **20** may be positioned at any convenient location in the path of the fan discharge. The location of the pressure probes between the fan and the compressor stages is referred to as station **2.5,** and the pressure signal produced at that point will be indicated as $P_{2.5}$.

The pressure transducer shown as probe **20** and sensor **28** is preferably a high response transducer which will respond to a range of pressure frequencies such as 0 to 1,000 Hz and at least 0 to 100 Hz. The pressure transducer shown as probe **18** and sensor **26** is a low response transducer which responds to low pressure frequencies such as those under 10 Hz. It will be apparent that the two transducers **26** and **28** may be combined into a single transducer which has the desired response over the entire frequency range of interest, with the selected frequencies being provided by means of filters.

The signal from the high response pressure sensor shown as block **28** is fed through a signal conditioning amplifier, not shown, into a band-pass filter **30** and which passes therethrough only the pressure frequencies of interest, approximately between 10 and 250 Hz depending upon the precise fan aerodynamics. The pressure frequencies outside the range of interest are attentuated. The output from the band-pass filter **30,** shown as ΔP, is fed to an AC to DC converter **32** which converts the AC output signal from the pressure transducer **28** into a DC signal for subsequent use. The DC output from converter **32,** which is proportional to the amplitude of the pressure signals in the frequency range passed through filter **30,** is then passed through a gain normalization amplifier, not shown, and fed as one of the two inputs into a comparator **34.**

The output from the low response pressure sensor shown as block **26** is also fed through an amplifier, not shown, into a low-pass filter **36** which may also contain a residual balance adjustment. The low-pass filter eliminates all frequency above, for example, 1 Hz, and preferably above one-fourth Hz. The output signal from low-pass filter **36** is essentially DC, and has an amplitude proportional to the absolute steady state pressure in the fan exhaust duct. The output from the low-pass filter **36** is then fed through a gain normalization amplifier, not shown, and then into a function generator **38** in which a reference trigger level signal ΔP_T is generated as a function of the absolute steady state pressure $P_{2.5}$.

FIG. **2** shows a plot of the variation in the trigger level ΔP_T as a function of the absolute steady state pressure $P_{2.5}$. The trigger level is shaped to eliminate inaccuracies which result in the operation of the near surge indicator at high altitudes, and under part power conditions. At the low pressures, under 5 psi, the trigger level ΔP_T is a constant which allows detection of high frequency pressure oscillations without being affected by the inaccuracy of the low frequency pressure sensor. In the mid-range, between approximately 5 and 20 psi, ΔP_T is set as a constant times $P_{2.5}$ which permits an equivalent $\Delta P_T/P_{2.5}$ to be effected. As illustrated in FIG. **2,** the constant shown as representative is 0.4.

At the high pressure regions, typically above 20 psi, where pressure levels are generally beyond those of interest to the near surge indicator but within the levels that must be tolerated by the pressure transducers, ΔP_T is raised to a high level to avoid inadvertent detection of disturbances such as pressure spikes produced by thrust augmentation equipment typically used in turbofan engines.

The implementation of the curve shown in FIG. **2** within block **38** can be accomplished by well-known electronic circuitry available to those skilled in the art.

The output from function generator **38,** ΔP_T is then fed as a second input to comparator **34.** Comparator **34** compares the high response signal ΔP with the trigger level signal ΔP_T, and if the high frequency signal ΔP exceeds the trigger level ΔP_T, an output signal is produced from comparator **34.** The output signal can be sent to an engine control requesting corrective action to prevent or alleviate surge, or the signal can be used to activate an alarm. Corrective action could include opening bleeds in the engine, opening the gas generator and/or fan bypass nozzles, decreasing fuel flow, or resetting variable fan and/or compressor stators. The alarm could include a light or buzzer, or a flag indicative of a control reset.

The advantage of the use of the trigger level as opposed to the ratio calculation is that operation is possible at low pressure levels where pressure sensors are characteristically inaccurate. Operation can also be inhibited above those pressure levels that are beyond the region of interest. Circuit implementation is simpler than that of the ratio calculation and also more noise free, thus resulting in improved accuracy.

By means of the present invention surge in a turbojet engine may be anticipated at a time much earlier than the prior art devices. By measuring the aerodynamic characteristics of the engine in the fan discharge portion, greater real time warning is available before actual engine surge occurs, thereby allowing more time for corrective action to be taken to avoid surge.

Although the invention has been described in its preferred embodiment for use in the fan discharge flow path of a turbofan engine, it is apparent that the concepts of the invention may be applied to a turbojet engine or to the compressor stage of a turbine engine where the pressure probes would be located in the compressor discharge flow path. The shape of the triggering signal would be modified accordingly, and the frequency range of the band-pass filter would be adjusted to pass those frequencies determined to be representative of the specific engine aerodynamics.